EDO UNIVERSITY IYAMHO

Department of Physics

PHY 119/129 General Practical

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Venue: Physic Lab, New Faculty of Science Building

Office hours: Monday and Wednesdays, 10.00am to 4.00 pm

Office: Room 5, Department of Physics, New Faculty of Science Building

Course Code: PHY119/129, General Practical (2 Units)

This course is divided into two sections:

Section one: Contains the first semester practical (1 Unit)

Section two: Contains the first semester practical (1 Unit)

Preamble:

Physics Practical offers a wide range of in-depth experimental investigations into key aspects of Physics. It has been designed in such a way that will develop some manipulative skills in handling some physics apparatus. It is an integral part of physics course, which reinforces some, if not all, the principles, theories and concepts you have learnt in Physics.

However, some experiments are designed to verify known laws while others are designed to obtain empirical relationships between two or more quantities. In every case, accurate and methodological observations are necessary and these should be taken with an intelligent realization of capabilities of the apparatus provided. It is therefore important that the students should possess a proper background for careful observations, precise measurement and theoretical knowledge to use the experimental results to their fullest advantage.

The units of records should be carefully written; otherwise the observations would become meaningless. Graphical presentation of experimental results is usually preferred in Physics because graphs provide the best means of averaging a set of observations and show dependence between quantities clearly.

Intended Learning Outcomes

At the completion of this course, students are expected to:

- To demonstrate phenomena and laws (that is, to support the theories of physics).
- To test hypotheses (to find out if theories are correct).
- To measure physical quantities (although it must be allowed that, for most of the quantities you will be asked to measure, you could more easily look them up in a book)
- To develop manipulative skills (learn how to use measuring devices).
- To provide training in the use of apparatus (to make sure that you don't damage expensive equipment).
- To communicate the results of the experiment or investigation to others (because your fellow student can benefit from your experience).
- To plan, implement, analyze the evidence from, and evaluate experiments (that is, to complete the requirement of your specification or syllabus).

Prerequisites: Students should be familiar with some basic concepts in elementary Physics and Mathematics.

Assignments: We expect to have up to ten individual practical assignments throughout in each of the semesters and a final examination also.

Grading: We will assign 10% each for any of the best six practical assignments among the ten, making 60% and 40% for the final examination.

Textbook: The recommended and referenced textbooks for this class are:

Title: PHY 119/129: Physics Practical Manual
Authors: Olayinka, S.A; Adekoya, M.A and Ukhurebor, K.E
Publisher:

Title: Physics for Scientists and Engineers
Authors: John W. Jewett, Jr
Publisher: Brooks/Cole, 8th Edition

Title: Fundamentals of Physics
Authors: Jeral Walker
Publisher: John Wiley & Sons, Inc, 8th Edition

Title: College Physics
Author: Chris Vuille, Paymond A. Serway and Jerry S. Fauchn
Publisher: Brooks/Cole, 8th Edition

General Overview

Safety comes first in any laboratory

If in doubt about any procedure, or if it seems unsafe to you, STOP. Ask your laboratory instructor for help.

Introduction

Physics Practical offers a wide range of in-depth experimental investigations into key aspects of Physics. It has been designed in such a way that will develop some manipulative skills in handling some physics apparatus. It is an integral part of physics course, which reinforces some, if not all, the principles, theories and concepts you have learnt in Physics.

However, some experiments are designed to verify known laws while others are designed to obtain empirical relationships between two or more quantities. In every case, accurate and methodological observations are necessary and these should be taken with an intelligent realization of capabilities of the apparatus provided. It is therefore important that the students should possess a proper background for careful observations, precise measurement and theoretical knowledge to use the experimental results to their fullest advantage.

The units of records should be carefully written; otherwise the observations would become meaningless. Graphical presentation of experimental results is usually preferred in Physics because graphs provide the best means of averaging a set of observations and show dependence between quantities clearly.

The Aims of a Course in Physics Practical are as Follows

- To demonstrate phenomena and laws (that is, to support the theories of physics).
- To test hypotheses (to find out if theories are correct).
- To measure physical quantities (although it must be allowed that, for most of the quantities you will be asked to measure, you could more easily look them up in a book)
- To develop manipulative skills (learn how to use measuring devices).
- To provide training in the use of apparatus (to make sure that you don’t damage expensive equipment).
- To communicate the results of the experiment or investigation to others (because your fellow student can benefit from your experience).
- To plan, implement, analyze the evidence from, and evaluate experiments (that is, to complete the requirement of your specification or syllabus).

Laboratory Report Guidelines

A student who makes a minimal attempt to follow the experimental scripts, acquires the relevant data, analyses and interprets the results and submits a report that is considered to be barely satisfactory, will obtain a mark of ~ 4/10.

A report that is well written (according to the guidelines given below) and indicates that the student has been diligent and conscientious in acquiring, analyzing and interpreting the data will obtain a first class mark of ~ 8/10.

To obtain higher marks a student must demonstrate that he/she has contributed more than was required by the scripts and has mastered some or all aspects of the experiment. In this respect, there is greater expectation for the level of understanding attained by students, who will be expected to do more background reading, to expand on the physics concepts mentioned in the scripts, and to present the experiment in a wider context.

Finding out about the Experiment

- Read the instructions thoroughly once. Do not worry if you do not understand every aspect of an experiment initially.
- Identify the pieces of apparatus and familiarize yourself with them.
- Try some test measurements to get a feel for the experiment.
- If there are still some points you feel you need to understand more clearly before taking the data, ask a demonstrator. This should not be a substitute for thought – the demonstrator will expect you to have thought about the problem.

Graph Plotting

Frequently, a graph is the clearest way to represent the relationship between the quantities of interest. There are a number of conventions to be noted as enumerated below:

- A graph indicates a relation between two quantities, x and y, when other variables or parameters have fixed values. Before plotting points on a graph, it may be useful to arrange the corresponding values of x and y in a table.
- Choose a convenient scale for each axis so that the plotted points will occupy a substantial part of the graph paper, but do not choose a scale which is difficult to plot and read, such as 2cm to represent 5 units or 1cm represents 3 units.
- Label each axis to identify the variable being plotted and the units being used. Mark prominent divisions on each axis with appropriate numbers.
- Identify plotted *points* with appropriate symbols, such as crosses, and when necessary draw vertical or horizontal *bars* through the points to indicate the range of uncertainty involved in these points.
- Often there will be a theory concerning the relationship of the two plotted variables. A linear relationship can be demonstrated if the data points fall along a single straight line. There are mathematical techniques for determining which straight line best fits the data, but for the purposes of this lab it will be sufficient if you simply make a rough estimate visually.

- The straight line should be drawn as near the mean of the all various points as is optimal. That is, the line need not precisely pass through the first and last points. Instead, each point should be considered as accurate as any other point (unless there are experimental reasons why some points are less accurate than others). The line of best fit should be drawn so that the number of data points above will be approximately equal to the number of data point below it and the points should be randomly distributed along the line. (For example, not all points should be above the line at one end and below at the other end).

Data Recording

The accuracy of every experiment is as good as the accuracy achieved in data record from the experiment. In order to minimize errors associated with data recording, the following points should be noted:

- Establish the range and number of readings to be taken.
- Before starting to take a series of serious measurements, it is worth spending a few minutes to lay out the apparatus in an orderly way and tidy any wiring and cables so that you can read and record the instruments efficiently and comfortably.
- Record the raw data with their units directly into your workbook, not on scraps of paper. The raw measurements should be included in your report.
- Check your observations as you proceed, look out for any measurements that are out of line with the rest. Plotting a graph as you take the data is often the simplest way to identify any rogue measurements.
- You may need to repeat some measurements to determine the random error associated with the measurement.

Equation of a Straight Line

Most graphs in Physics practical are Straight line graphs (linear graphs) and sometimes we have non-linear graphs, which can be transformed into linear graphs for easier interpretation. The general equation of a straight line (linear graph) is given by

$$y = mx + c \qquad (1.1)$$

where x and y are the independent and dependent variable respectively, m and c are constants representing slope/gradient and intercept respectively. Linear Graph with zero and c intercept are shown in Figure 1.1.

<u>Y-Intercept</u>: is define as the value of y when x = 0. From equation 1.1, if $x = 0$ and $y = mx + c$ then $y = c$

X-axis X-axis

Figure 1.1 – Sketch of Linear Graph with zero and c intercept respectively.

X-Intercept: is define as the value of x when y = 0. Substituting in equation 1.1,

If $y = 0$ and $y = mx + c$

$0 = mx + c$

$mx = -c$

$x = \frac{-c}{m} = \frac{y\text{-}intercept}{gradient}$ (1.2)

Gradient / Slope (m):

$Slope, m = \frac{Change\ in\ y\text{-}value(\Delta y)}{Change\ in\ x\text{-}value\ (\Delta x)}$ (1.3)

Presenting Your Work

The primary deliverable of an experiment is a measurement of a physical quantity together with its error. The written report should contain all the evidence for this result in a form that can be checked by a third party. A good report should include the following:

- A summary page at the start of the report showing the results and conclusions
- An introduction
- A brief outline of the method / theory behind the experiment
- The raw data and any derived data including errors
- A proper error analysis of the derived results, including the error presented as a percentage and the largest/most significant error identified
- Easy to follow examples of all calculations
- Any graphical interpretations of the data including error bars
- Any line fit results and interpretations of graphs
- A conclusion that includes derived numbers quoted to a sensible number of decimal points
- Answers to any questions asked in the script should be given. It is up to you how these appear in the report

Error Analysis

Importance of Errors Estimation

A measurement of a physical quantity is unlikely to yield exactly the true value. An estimate of the size of the likely difference between the true and measured value is important if significant conclusions are to be drawn from the result. Since the true value is not known, the most likely size of the error on the measured value must be estimated and quoted along with the result.

Types of Error

Uncertainty in a measurement can arise from three possible origins: the measuring device, the procedure of how you measure, and the observed quantity itself. Usually the largest of these will determine the uncertainty in your data. There are two basic different types of error which are systematic and random errors.

Systematic Error

Systematic error or systematic errors always bias results in one specific direction. Your result will consistently be too high or too low. An *example* of a systematic error follows. Assume you want to measure the length of a table in cm using a meter stick. But suppose the meter stick has been manufactured incorrectly or the stick is made of metal that has contracted due to the temperature in the room, so that the stick is less than one-meter long. Clearly all the calibrations on the stick are smaller than they should be. Your numerical value for the length of the table will then always be too large no matter how often or how carefully you measure. Another example might be reading temperature from a mercury thermometer in which a bubble is present in the mercury column.

Systematic errors are usually due to imperfections in the equipment, improper or biased observation, or by the presence of additional physical effects, you did not take into account. (An example might be an experiment on forces and acceleration in which there is friction in the setup and it is not taken into account!)

In performing experiments, try to estimate the effects of as many systematic errors as you can, and then remove or correct for the most important. By being aware of the sources of systematic error beforehand, it is often possible to perform experiments with sufficient care to compensate for weaknesses in the equipment.

Random Error

In contrast to systematic error, random errors are unbiased - meaning it is equally likely that an individual measurement is too high or too low. Random uncertainty means that several measurements of a quantity will not always come out the same but will spread around a mean value. The mean value will be much closer to the “real” value than any individual measurement.

From your everyday experience you might now say, "Stop! Whenever I measure the length of a table with a meter stick I get exactly the same value no matter how often I measure it!" This may happen if your meter stick is insensitive to random measurements, because you use a coarse scale (like mm) and you always read the length to the nearest mm. But if you would use a meter stick with a finer scale, or if you interpolate to fractions of a mm, you would definitely see the spread. As a general rule, if you do not get a spread in values, you can improve your measurements by using a finer scale or by interpolating between the finest scale marks on the ruler.

How to reduce the effect of random error?

Consider the following *example*. Ten people measure the time of a sprinter using stopwatches. It is very unlikely that each of the ten stopwatches will show exactly the same result. You will observe a spread in the results. Even if each started their watch at exactly the same time (unlikely) some per-sons will have stopped the watch early, some of them late. But if you *average* the times of the ten stop watches, the *mean* value will be a better estimate of the true value than any individual measurement, since the effects of the people who stop early will compensate for those who stop late. In general, making multiple measurements and averaging can reduce the effect of random uncertainty.

Errors in Reading Instruments

The error in reading a scale, for example on a ruler or on an analog meter, can arise from a number of sources:

Parallax Error: If the line of sight is not at right angles to the scale, a gap between the object being measured (the pointer in the case of the meter) and the scale will cause an error. This can be reduced by careful alignment of the eye, a process aided in better quality meters by a mirror built into the scale so that the pointer and its image can be lined up to ensure the scale is viewed at right angles.

Zeroing Error:Most instruments have the provision to set the reading to zero when zero input is present. If the instrument is not correctly zeroed, actual reading will be offset by the offset of the zero. This offset can be measured and a correction applied but it is good practice to always zero the instrument so that the reading can be used without correction.

Back lash Error: While measuring a physical quantity there may be an error due to wear and tear in the instruments like screw gauge or spherometer (instrument for measuring the curvature of a surface) due to defective fittings. Such an error is called back lash error and can be minimized in a particular set of measurements by rotating the screw head in only one direction.

End Correction: Sometimes the zero marking of the metre scale may be worn out. Unless we are careful, this will lead to incorrect measurements. We must therefore compensate for this by shifting our reference point.

Errors due to changes in the Instrument parameters: Usually in experiments involving electrical quantities, the values of the electrical quantities change during the course of the experiment due to heating or other causes. For example, the value of the resistance of a wire will increase because of current passing through it. This will lead to errors, which are generally difficult to calculate and compensate for. To some extent this can be avoided by not allowing current to flow through the circuit while observations are not being taken.

Defective Calibration: Occasionally instruments may not be properly calibrated leading to errors in the results of measurement. This type of error is not easily detected and compensated for. This is a manufacturer's defect and if possible the instrument should be calibrated against standard equipment.

Observational: These arise due to errors in judgment of an observer when reading a scale to the smallest division.

Environmental: These arise due to causes like unpredictable fluctuations inline voltage, variation in temperature etc. They could also be due to mechanical vibrations and wear and tear of the systems. There could be a random spread of readings due to friction say, wear and tear of mechanical parts of a system.

Scale Reading Errors: The scale can only be read to some accuracy which depends on how finely the scale is engraved. A conservative rule of thumb is assumed the scale can be read to a half of the smallest division. However, a fifth of the smallest interval can often be achieved. In practice, you make a judgment based on your use of the particular instrument tempered with experience and common sense. A digital scale can be read ± 1 in the least significant digit displayed provided the reading is stable. As for analogue instruments there will be a zeroing error.

Calibration Errors: The accuracy of the reading of every instrument, analogue or digital, will depend on the calibration. Manufactures will usually supply details of the accuracy of the calibration of the instruments at the point of manufacture. A data sheet from the manufacturer with this information should be available close to the equipment in the laboratory. Unless told otherwise in the instructions, you can assume the calibration is correct. However, possible calibration errors should not be ignored if you have to do any trouble-shooting on the data.

Calibration errors may take the form of an overall multiplicative constant. Instruments will often have some internal adjustment to set this. More commonly, calibration errors will manifest themselves as small deviations around the marked scale due, for example, to the quality of construction of the instrument. These can be accounted for by calibrating the scale against an (expensive) standard instrument. If this is advisable, the instructions will tell you.

Numerical Estimates of Error

Estimation of error can be approached using different approximation techniques depending on the nature of the experiment and data acquired from such an experiment. You should note which technique you are using in a particular experiment. Some of error estimation techniques are discussed below:

Upper Bound

Most of our measuring devices in this laboratory have scales that are coarser than the ability of our eyes to measure see fig. 2.1.

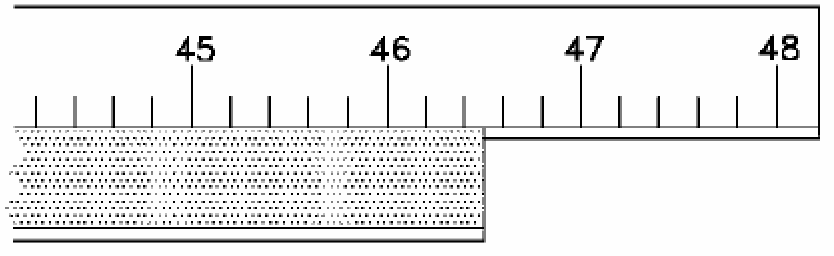

Fig. 2.1: Meter Stick.

For example, in fig. 2.1 above, where we are measuring the length of an object against a meter stick marked in cm, we can definitely say that our result is somewhere between 46.4 cm and 46.6 cm. We assume as an *upper* bound of our uncertainty, an amount equal to *half* this width (in this case 0.1cm). The final result can be written:

l = (46.5 ± 0.1) cm.

Estimation from the Spread (2/3 Method)

For data in which there is random uncertainty, we usually observe individual measurements to cluster around the mean and drop in frequency as the values get further from the mean (in both directions).[1] Find the interval around the mean that contains about 2/3 of the measured points: *half* the size of this interval is a good estimate of the uncertainty in each measurement.

Example:

You measure the following values of a specific quantity:

9.7, 9.8, 10, 10.1, 10.1, 10.3

The mean of these six values is 10.0. The interval from 9.75 to 10.2 includes 4 of the 6 values; we therefore estimate the uncertainty to be 0.225. The result is that the best estimate of the quantity is 10.0 and the uncertainty of a single measurement is 0.2.

Square-Root Estimation in Counting

For inherently random phenomena that involve counting individual events or occurrences, we measure only a single number N. This kind of measurement is relevant to counting the number of radioactive decays in a specific time interval from a sample of material, for example. It is also relevant to counting the number of Lutherans in a random sample of the population. The (absolute) uncertainty of such a single measurement, N, is estimated as the square root of N. As an example, if we measure 50 radioactive de-cays in 1 second we should present the result as 50 ± 7 decays per second. (The quoted uncertainty indicates that a subsequent measurement performed identically could easily result in numbers differing by 7 from 50.)

Percentage Error

The actual error is the amount by which the experimental value differs from the true value. For example, if a man measures the length of a rope to be 3m instead of 3.2m. The actual error in the measurement is 0.2m.

Then, the relative or fractional error $= \dfrac{Actual\ Error}{True\ Value}$ (2.1)

In general, Percentage Error = $\dfrac{Actual\ Error}{True\ Value} \times 100\%$ (2.2)

Percentage Difference

This involves comparing two results or measurements, that is, we intend to find the percentage difference between the two.

Percentage difference $= \dfrac{Deviation}{Average\ Value} \times 100\%$ (2.3)

Uncertainties

The accuracy with which a given measurement can be made is increased by obtaining the average of a number of independent readings. If M is the mean value of the individual reading and d is the average of the deviations from the mean, then the measured quantity is recorded as:

$Current\ value = M \pm d$ (2.4)

and the percentage uncertainty in the measured quantity is given as:

$Percentage\ uncertainty = \dfrac{d}{M} \times 100\%$ (2.5)

The Distribution of Measurements

A set of measurements of the same quantity free of systematic errors will typically show a distribution about the true value. The best estimate of the true value of the quantity will be given by the mean of these readings:

Mean: $\bar{x} = \dfrac{\Sigma x_i}{N}$ (2.6) where N = number of readings

$x_1, x_2, ...x_i.....x_N$ = the N values of x

The error on a single reading is given by the spread of a distribution.

Standard error on a single reading: $$\sigma_{n-1} = \sqrt{\frac{\Sigma\left(x_i - \bar{x}\right)^2}{N-1}} \quad (2.7)$$

Multiple readings reduce the error on the mean by the factor $\frac{1}{\sqrt{N}}$

Standard error on the mean: $$\Delta x = \sqrt{\frac{\Sigma\left(x_i - x\right)^2}{N\left(N-1\right)}} = \frac{\sigma_{n-1}}{\sqrt{N}} \quad (2.8)$$

Error in Slope

The standard Error in slope may be estimated from the points by the formula

Error in slope $$= \frac{4w}{nR} \quad (2.9)$$

where $R = x_{\max} - x_{\min}$ *, n=number of points and w= distance drawn parallel to y-axis*

Experiment 1 - Measurement

Aims

- To learn how to make measurements of length with a meter stick, a Vernier caliper and a micrometer.
- To learn to make dimensional analysis calculations between English and SI systems of measurements.
- To understand the relationship between the construction of a measuring instrument and the precision of the measurements made with it.
- Become familiar with elementary statistical treatment of data.

Apparatus: Meter stick, 15 to 30 cm ruler, 12.5cm Vernier calliper, 25mm micrometer, standard sizes of the following; rectangular aluminium blocks, aluminium and brass cubes, aluminium and brass cylinders: 10cm lengths of various gauge copper wire.

Introduction

Meter Stick / Ruler Measurement

When making measurements using a meter stick or ruler keep as shown in Fig.3.1 the following suggestions in mind:

- Since the end of the meter stick or ruler may be worn or damaged, start the measurement at an intermediate mark.
- When you make a measurement with the meter stick or ruler place the device on edge. This will reduce parallax errors. (Parallax errors are sight errors made by viewing the device from a flat position).
- Estimate your measurement to the nearest 0.5 mm. The last digit of your measurement, which is an estimate, should be 0 or 5.

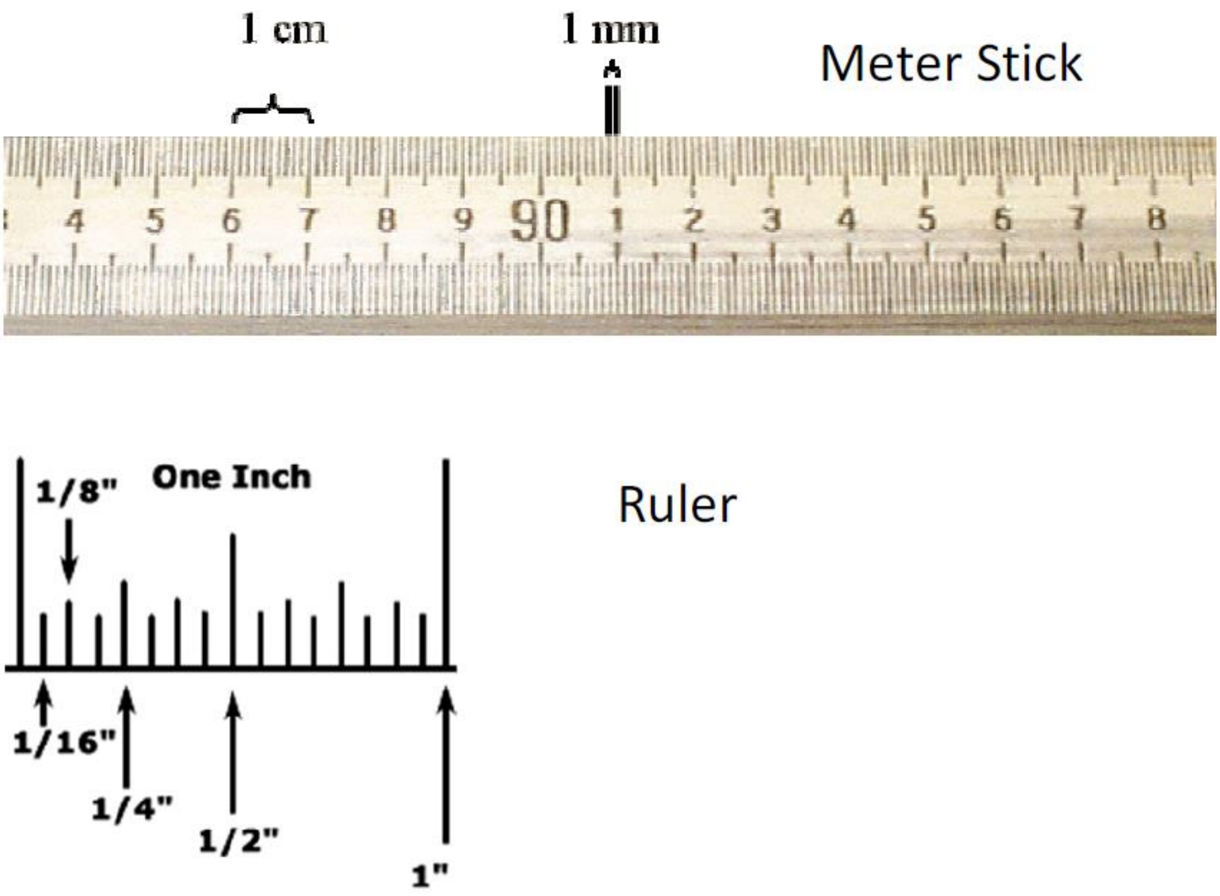

Fig.3 .1: Meter Rule

Vernier Calliper

The Vernier calliper consists of two SI scales and two English scales as shown in the figure 3.2 below.

The fixed scales have a jaw at one end. The SI fixed scale is divided into cm and mm. The fixed English scale is divided into inches and 8ths of inches.

The moving scales (Vernier) are attached to the moving jaw that slides across the fixed scale. The moving SI scale is divided into ten divisions and the moving English scale is divided into 8 divisions.

To use the calliper, separate the jaws, place the object to be measured between them, and close the jaws firmly.

Centimeters and tenths of cm are read on the fixed scale. Hundreds of cm is read on the moving scale.

Inches and 8ths of inches are read on the fixed scale and 64thof inch are read on the moving scale.

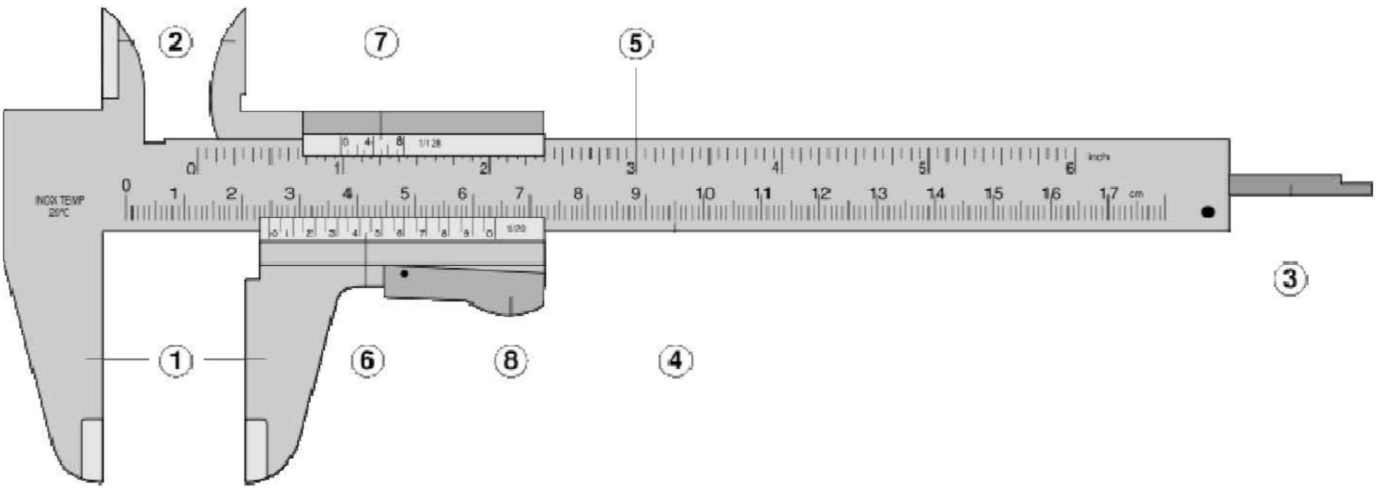

Fig. 3.2: Vernier Calliper

Lower Jaws

Upper Jaws

Depth Gauge

Fixed SI scale

Fixed English scale

Moving SI scale

Moving English scale

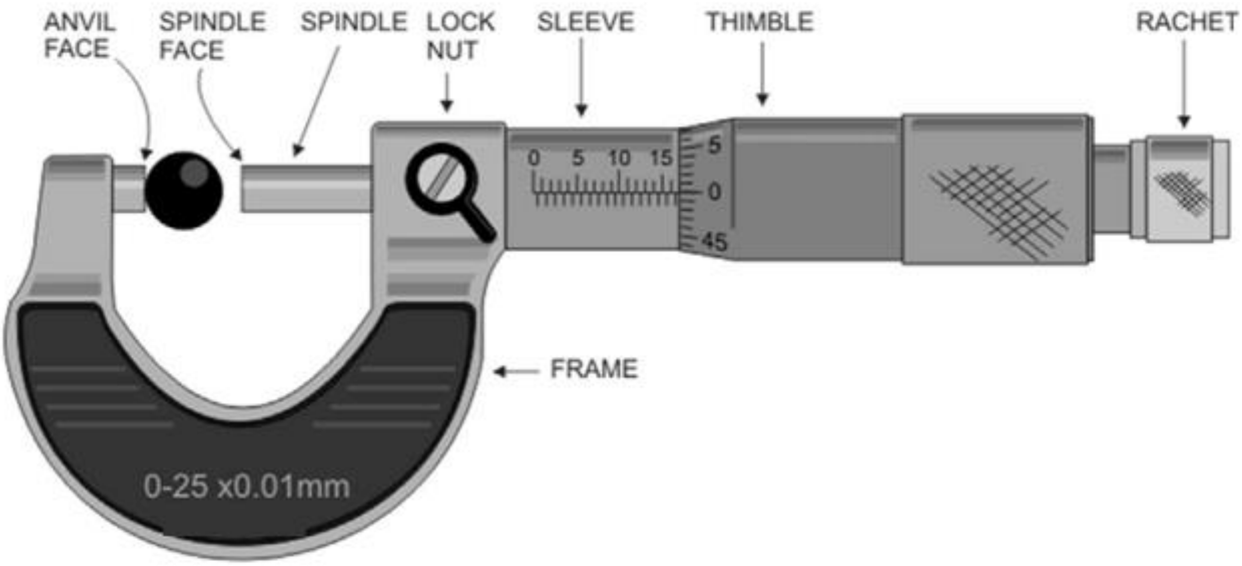

Fig.3.3: Micrometer screw gauge

Procedure:

1. Meter Stick

- Measure the width of your laboratory table and record this measurement to the nearest 0.5 mm.
- Repeat the measurement but start the measurement at a different mark on the meter stick.
- Make a third measurement, this time from the opposite end of the table.
- Record your data in the Tab.3.1 provided.

2. Meter Stick

- Measure the length, width, and thickness of the block furnished by the instructor. Make each measurement three times.
- Record all of your data in the Tab.3.1 provided.
- Average the measurements.
- Use the average values and calculate the volume of the block.

3. Ruler (English System)

- Measure the length, width, and thickness of the block furnished by the instructor. Make each measurement three times using the English scale.
- Average the measurements.
- Record all of your data in the Tab.3.1 provided.
- Use the averages to calculate the volume of the block.

Table 3.1 Readings:

Meter Stick	**Reading 1**	**Reading 2**	**Reading 3**	**Average / Mean**
Width of Table				
Length of Block				
Width of Block				
Thickness of Block				
Volume of Block				
Ruler				
Length of Block				
Width of Block				
Thickness of Block				
Volume of Block				

4. Vernier Calliper

- Make three measurements of the length (height) and diameter (internal and external) of the cylinder furnished by the instructor.
- Record your measurements in the Table 3.2 provided.
- Average the measurements.
- Calculate the volume of the cylinder ($V=\pi r^2 h$)

Table 3.2 Readings:

Cylinder	**Reading 1**	**Reading 2**	**Reading 3**	**Average / Mean**
Length / Height				
External Diameter				
Internal Diameter				
Volume of Cylinder				

5. Micrometer

- Begin by closing the micrometer gently to observe the zero reading. If the reading is off zero, ask the instructor to adjust the micrometer or record your zero error.

- Open and close the micrometer a few times to get a “feel” of how it operates. Open the micrometer and try to read it at a random position.
- Place a piece of wire between the anvil and the spindle of the micrometer.
- Close the micrometer on the wire using the ratchet.
- Read the micrometer to the nearest thousandth of a mm and record your measurement as diameter in Tab.3.3 provided.
- Convert your measurement of diameter to cm and record the value in Tab.3.3 provided.
- In a similar manner measure and record the diameters of other wires of different gauges.
- Consult the “Properties of Copper Wire” table provided for the “true” gauge diameter.
- Calculate absolute and relative errors for each wire and record these in the table provided.

Table 3.3 Readings:

Cooper Wire	**Reading 1**	**Reading 2**	**Reading 3**	**Average / Mean**
Gauge 1				
Gauge 2				
Gauge 3				
Gauge 4				
Gauge 5				

6. Comparative Precision

- Measure the dimensions of the block provided successively with the meter stick, Vernier calliper, and micrometer, using each instrument to its described precision.
- Record your measurements in the Tab.3.4 provided.
- Calculate the volume of the block using measurements from each measuring device and record these in Tab.3.4 provided.
- Compare the precision.

Table 3.4 Readings:

Instrument	**Length**	**Width**	**Thickness**	**Volume**
Meter Stick				
Vernier Calliper				
Micrometer				

Questions:

1. Why should a meter stick be placed on edge when making measurements?
2. Why should measurements be started at a mark other than the end of the meter stick?

3. What is the smallest unit on the meter stick, Vernier calliper and micrometer, respectively?
4. How could you use a meter stick to determine the thickness of a single sheet of paper if a micrometer was not available?
5. How can a micrometer be used to measure the inside diameter of a hollow cylinder?
6. Paul measured the dimensions of a block as 1.5 cm X 1.3 cm X 1.0 cm and recorded the volume as 1.950cm^3. Peter measured the same block dimensions as 1.485 cm X 1.314 cm X 0.986 cm and recorded the volume as 1.92 cm^3. Which volume is more reliable in terms of the data from which it was calculated? Why is it more reliable?
7. What measurement magnitudes should be read on the fixed (main) scale of the Vernier calliper?
8. What measurement magnitudes should be read on the moving (Vernier) scale of the Vernier calliper?